POLARIZATION AND DEPOLARIZATION CURRENT STUDY IN POLYMERIC INSULATION CONTAINING VOIDS

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I dedicate this project report to

my beloved mother and father
and
family

my supportive friends
Zurina
"Budak Master Cute"

Thanks for pushing me to the limit so that I can
finish my report on time…

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In the Name of Allah, the Beneficent, the Merciful.

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ABSTRACT

PDC testing is one of the dielectric diagnostic techniques based on time domain measurement. It is a non-destructive dielectric testing which is used to determine the conductivity of insulation. Voids are inevitable in HV insulations which can occur during manufacturing. Numerous studies have been carried out to assess the condition of solid and liquid insulations using PDC. However, such studies on voids have been found lacking. This project presents PDC studies on insulations containing voids. PDC measurements were conducted on new Silicone Rubbers (SiR) samples containing various sizes of voids as well as multiple number of voids. DC conductivity of the samples were calculated by using PDC Analyzer via LabVIEW program and the PDC curves were plotted by using MATLAB. Result from this study showed that different sizes and numbers of void affected the conductivity of SiR samples. Increasing sizes of void as well as increasing number of voids resulted in increase in polarization and depolarization currents as well as the conductivity of the SiR samples. Thus study suggests that PDC measurement can be a tool in analysing and detecting voids in solid insulation.

ABSTRAK

Pengujian PDC merupakan salah satu teknik diagnostik dielectrik berdasarkan pengukuran domain masa. Ia merupakan pengujian dielectrik tidak musnah yang digunakan untuk menentukan konduktiviti penebatan. Void tidak dapat dielak dalam penebatan HV yang boleh berlaku semasa pembuatan. Banyak kajian telah dijalankan untuk menilai keadaan penebatan pepejal dan cecair menggunakan PDC. Walau bagaimanapun, terdapat kekurangan kajian dilakukan tentang void. Projek ini akan membentangkan kajian PDC terhadap penebatan yang mengandungi void. Ukuran PDC telah dijalankan pada sampel getah silikon (SiR) yang baru dan mengandungi pelbagai saiz void serta beberapa bilangan void. Pengaliran DC dalam sampel dikira dengan menggunakan PDC 'Analyzer' melalui program LabVIEW dan lengkung PDC telah diplotkan dengan dengan menggunakan MATLAB. Keputusan menunjukkan bahawa saiz void dan bilangan void yang berbeza akan menjejaskan tahap pengaliran sampel. Peningkatan saiz dan pertambahan bilangan void mengakibatkan peningkatan arus polarisasi dan arus depolarisasi serta konduktiviti sampel SiR. Kajian ini mencadangkan bahawa pengukuran PDC boleh menjadi alat dalam menganalisis dan mengesan void dalam penebatan pepejal.

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LIST OF ABBREVIATIONS

HV	-	High Voltage
DC	-	Direct Current
SiR	-	Silicone Rubber
SiO_2	-	Titania
Al_2O_3	-	Spherical Alumina
ZnO	-	Zinc Oxide

LIST OF SYMBOLS

C	-	Capacitance
U	-	Voltage
t	-	Time
i_p	-	Polarization current
ε_o	-	Vacuum Permittivity
σ	-	Conductivity

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CHAPTER 1

INTRODUCTION

1.1 Background

The most critical part in high voltage (HV) equipment such as cable is insulation. Based on literatures, insulation is the core reason for faults and problems in HV equipment. Equipment such as transformers and cables need to operate continuously in order to maintain a reliable and efficient electricity supply [1]. However, it is inexorable that the insulation of the equipment will deteriorate under a combination of thermal, electrical, mechanical, chemical and environmental stresses during the course of operation. Thus, weaknesses like voids will emerge. Void or cavity is a small gas-filled existence in solid dielectrics and may be formed during manufacturing or fabrication process. The voids are filled with medium of lower dielectric and lower permittivity. Therefore, the electric field stress in the void will be higher than the main part of the insulator.

Due to this high stress of the electrical fields of voids in insulation, internal discharges may occur. It is crucial to monitor the insulation condition of equipment to plan overhaul and replacement to prevent the system from any unpredicted failure [1]. Several diagnostic techniques have been developed and used to determine the condition of power equipment insulations. Among these techniques, Polarization and Depolarization Current (PDC) measurement is gaining popularity due to its ability to access the conductivity of HV insulations within the initial periods after a DC step voltage application without destructing the insulations [2].

1.2 Problem Statement

Silicone rubber, as an advanced internal insulating material, occupies the majority of the market in extra high voltage prefabricated cable accessories. This is due to its excellent insulation and mechanical performance [3]. Housing materials of polymer insulators is reported as one of the uses of silicone rubber [4]. However, during the processes of installation and fabrication, there is a probability that defects to occur in the insulation such as protrusions, void and conductive contaminant. Voids in solid insulators are hardly seen.

Polarization and Depolarization Current (PDC) technique has been gaining popularity in condition monitoring of HV insulation due to its non-destructive nature and ability to detect moisture and/or insulation conductivity. Numerous researches have been reported on the employment of PDC to detect anomalies in solid insulations like transformer kraft paper, polymeric insulations of cables or moisture in liquid insulations like transformer oil. However, studies on insulations containing voids has not been reported.

1.3 Objectives

i. To compare the patterns of polarization and depolarization current of solid insulator with and without void.
ii. To compare the patterns of polarization and depolarization current of solid insulator of different sizes of void.
iii. To compare the patterns of polarization and depolarization current of solid insulator of different number of voids.

1.4 Scope of Study

In this study:

- PDC studies will be conducted on SiR insulation.
- PDC analysis will be limited to new SiR samples containing voids.
- The moulding of samples will be carried out in the Polymer Laboratory, Faculty of Chemical Engineering, Universiti Teknologi Malaysia.
- The PDC testing will be carried out in the High Voltage Laboratory of Faculty of Electrical Engineering, Universiti Teknologi Malaysia.

1.5 Thesis Outline

This project report consists of five chapters outlined as follows:

Chapter 1 explains a brief introduction and overview about this project, objectives, problem statement and scope of the research.

Chapter 2 discusses on the theory and literature review related to this project. It contains the basic concept and knowledge about insulation material, polymeric insulation and PDC measurement. This chapter also summarizes the comparative studies that were done based on previous research about PDC measurement technique on HV insulations.

Chapter 3 discusses on the methodology and the flow of the project. It covers a detailed discussion on how the samples were prepared and the experimental procedure of PDC measurement that was conducted in IVAT's laboratory.

Chapter 4 presents the PDC measurement test results of each samples along with the discussions of the results.

Chapter 5 concludes the project based on the results and discussion that were covered in Chapter 4. Finally, a few recommendations are highlighted for future work improvement and development related to this project.

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